

SYNOPSIS

Habitat as Architecture: Integrating Conservation Planning and Human Health

Robert F. Baldwin, Robert B. Powell,
Stephen R. Kellert

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INTRODUCTION

The current resurgence in popular awareness of the environment is dominated by concern for energy and food sustainability. In the meantime, the biodiversity crisis continues to magnify (Brooks et al. 2006). While incidents like the Gulf of Mexico oil spill help focus public attention on how unsustainable energy use patterns are for human health and well-being and wildlife conservation, many other practices commonly considered “sustainable” are not so for biodiversity. Agricultural ecosystems may be perceived as sustainable if they produce organic products, yet the most extensive certified organic farms have many of the same homogenous landscape characteristics as non-organic industrial farms (reviewed in Bengtsson et al. 2005). Industrial production of biofuels threatens vast areas of native grasslands and forests (Groom et al. 2008; Fletcher et al. 2010). Likewise, green housing developments typically use only structural or aesthetic aspects of nature at the expense of protecting habitat (Milder 2007). Even in relatively natural suburbs, the most sensitive species often “fall out” and the more tolerant proliferate (McKinney 2002; Hepinstall et al. 2008).

Sustainable development as currently defined is based on the assumption that human well-being, both physical and mental, is reliant on intact, functional environments; a human population with the capacity to support economic growth and participate in governance; a transparent, efficient, and equitable political and governance system; and a

diverse economic base that is adaptable to changing conditions and does not deplete the resources it is dependent upon (e.g., UNDSD 2007). Although the themes of Social Capacity, Environmental Health, Economic Development and Growth, and Effective Governance are thought to be interdependent, and all necessary to achieve sustainable development (e.g., Powell et al. 2009), the predominant rationale for biodiversity conservation is often thought of as biocentric (i.e., nature has intrinsic value; Rolston 1989). However, an abundance of research has revealed that ecosystems with a full complement of interacting species have significant utilitarian value to humans by providing dividends for human health (e.g., Kellert 2005; Balvanera et al. 2006) and enhancing quality of life (e.g., Kellert et al. 2008).

There remains a disconnection, though between biodiversity conservation and emerging issues in sustainability. In this essay, we suggest an integration of approaches such that remaining habitat puts biophysical limits on expansion of the “human footprint”. We also suggest that by employing biophilic design traditional conservation planning will be improved because it will integrate human physical, social, and psychological well-being. The goal of biophilic design is to integrate social and natural sciences to produce human living environments that sustain a human-nature connection; i.e., provide psychological benefits (Kellert et al. 2008).

HABITAT FOR SENSITIVE SPECIES AS BOUNDARIES FOR GROWTH

Many sensitive organisms, e.g., amphibians, reptiles, migrant birds, mesocarnivores, persist or have re-inhabited

larger habitat fragments in human-dominated landscapes; these fragments need to be identified and protected for biodiversity conservation (e.g., Ray et al. 2005; Baldwin and deMaynadier 2009). In this essay, we are suggesting they will also provide the necessary spatial boundaries for growth in the human footprint and deliver multiple ecosystem services. There are existing lines of evidence to suggest that using habitat of sensitive species to put “boundaries” on human development is already in use and could preserve ecosystem services, enhance human quality of life, and facilitate sustainable development. From an ecosystem services perspective, biological assessments using sensitive indicator species have been applied throughout the world as indicators of water quality (USEPA <http://www.epa.gov/bioindicators/html/indicator.html>, Boonsoong et al. 2010), air quality (e.g., Conti and Cecchetti 2001), forest integrity (Lindenmayer et al. 2006), and other environmental conditions (Hilty and Merenlender 2000). We suggest intentionally identifying and protecting habitat patches retaining native biodiversity in and around cities, towns, and intensively used agricultural areas not only for local-scale biodiversity conservation (as in the work of local land trusts) but to restore connectivity and functioning ecosystems at greater scales and impose geographic boundaries to development.

INTEGRATING SOCIAL GOALS

Research has suggested that healthy functioning ecosystems are associated with higher human quality of life including reduced crime, enhanced human health, and psychological restoration (e.g., Kellert 2005; Kellert et al. 2008). As an indicator of the value humans place upon functioning ecosystems, in many areas of the world human populations have been migrating to settlements around protected areas for their ecosystem services such as water, wildlife, and fire-wood as well as for economic opportunities (Wittemyer et al. 2008).

Effective sustainable design and development combines both lessening and avoiding adverse impacts on natural systems, as well as enhancing human health, productivity, and physical and mental well-being through fostering beneficial connections to nature. The latter objective builds on the view that humans possess an inherent need to affiliate with natural systems in ecologically and culturally meaningful ways, an affiliation referred to as biophilia (Kellert and Wilson 1993). The human mind and sensory systems evolved largely in a biological landscape. Evidence increasingly supports that human fitness relies on a matrix of instrumental connections to natural features and processes. Social, psychological, and health benefits of interacting with healthy and functioning natural

environments include reducing stress, pain, and depression (e.g., Hartig et al. 2008); enhancing physical and mental resilience and health (e.g., Hartig et al. 1991, Frumkin 2003); improving childhood development, attention, and academic performance (e.g., Kahn and Kellert 2002); improving adult work performance and productivity (e.g., Heerwagen 2000); and reducing crime (e.g., Kuo and Sullivan 2001). The pursuit of sustainable habitats and communities, both human and non-human, must, therefore, not just minimize adverse environmental impacts, but provide landscape level human interactions with nature.

PROTECTING SENSITIVE SPECIES WHERE PEOPLE LIVE AND WORK

We live on a human-dominated planet. Recent estimates suggest that approximately 20% of global terrestrial ecosystems have minimal human impact (Sanderson et al. 2002a; Woolmer et al. 2008). While we have traditionally relied upon protected areas for biodiversity conservation, global protected areas coverage are 4.06% for marine environments and 14.36% for terrestrial ecosystems (WDPA 2008). Historically people have chosen to settle in those areas which often also supported rich biodiversity; areas where it is unlikely that any new protected areas will be established (Margules and Pressey 2000). In the United States—even with its extensive system of public lands and regulatory structures (e.g., the Endangered Species Act)—60% of the land surface is privately owned, 95% of federally listed endangered species occur on these private lands (Hilty and Merenlender 2003), and at least 20% of the private lands have been converted to roads, houses, and other development since 1950 (Brown et al. 2005).

Nonetheless, many sensitive organisms still persist in or have re-inhabited human-dominated landscapes, in larger habitat patches that are currently threatened by development (Theobald 2003, Baldwin and deMaynadier 2009). Conservation biology, rather than focusing solely on protecting the pristine, seeks to integrate habitat conservation with human activities wherever possible (Miller and Hobbs 2002). We suggest a renewed effort to identify these patches and conserve and connect them, research and document multiple ecosystem services delivered, and in terms of policy, use the geographic infrastructure to encourage sustainable growth.

Given recent global amphibian declines (Mendelson et al. 2006), it would be beneficial to examine how useful the habitat needs of amphibians in urbanizing and agricultural environments would be as boundaries for human growth and in predicting human sustainability. Many amphibians and reptiles require entire wetland–upland landscapes with fairly intact forest (Semlitsch 2000), but

still persist in low-density residential areas even in close proximity to major urban areas (Homan et al. 2004; Baldwin et al. 2006). In those areas where human land use pressure is greatest, amphibian habitat may supply a useful template with which to manage growth and ensure the provision of some ecosystem services.

BIOPHILIC DESIGN: INTEGRATING HABITAT WITH HUMAN HEALTH AND WELL-BEING

Developing habitat-based architecture for global sustainability requires a new level of collaboration by conservation biologists and recognition by the public that human well-being in the long run is directly linked to the ecological health and resilience of our own communities. Currently city, county, and regional land-use planning can be a spatially and temporally explicit, modeling-based process. However, many land-use planners lack backgrounds in biological sciences necessary to incorporate or interpret habitat models, which presents a challenge to using habitat for sensitive species as a template for human development but an opportunity for habitat modelers to collaborate with land use planners at multiple scales.

Land use decision-making processes involving land trusts, federal, state and local agencies, and private landowners provide many opportunities for conservation biologists to integrate habitat with development plans (Theobald et al. 2000; Powell 2010). There is a plethora of decision-support tools focused on habitat conservation that will be useful for using habitat as architecture (reviewed in Crooks and Sanjayan 2006, Moilanen et al. 2009). For example, occupancy modeling packages (e.g., PRESENCE), connectivity modeling packages (e.g., Corridor-Design, Circuitscape), multi-target nature reserve selection packages (e.g., MARXAN), and spatially explicit population viability modeling packages provide highly specific habitat conservation models yet require advanced ecological and computing expertise to execute.

Researchers in the fields of landscape ecology and conservation biology have long urged active integration of disciplines to bridge scientific-planning gaps (Opdam et al. 2002; Theobald et al. 2000). In the U.S., models for implementing conservation design are provided by the burgeoning cooperative activities of land trusts and land developers (e.g., “conservation buyer projects”; Milder 2007). Europe has multinational spatial planning integrating environmental goals at regional to local scales (Albrechts et al. 2003). Green infrastructure projects embrace habitat conservation but none have fully embraced the value of indicator species and biological function (e.g., Tzoulas et al. 2007). Most major conservation groups (e.g., The Nature Conservancy, Wildlife Conservation

Society) employ scientists who routinely work with stakeholders and the general public throughout the world to integrate science with planning (Sanderson et al. 2002b). Rarely though do the public, land use planners, habitat ecologists, and ecosystem services experts convene to design optimal landscapes for sustainability.

Little attention has been devoted to identifying human values of nature and associated physical and mental benefits derived from landscape features and natural processes, particularly when these environmental systems are damaged or impaired. Moreover, little conceptual or methodological progress has focused on linking species, habitats, and landscape level features and functions with human environmental values and related dependencies on experiential contact with these natural systems. In effect, human and natural systems can complement and mutually reinforce one another. Restoration efforts can enhance biological diversity, ecological productivity, biogeochemical flux, well-developed soils, complex food webs, habitat diversity, and other indicators of natural system resilience and integrity (e.g., Dobson et al. 1997). These complex natural systems should, in turn, foster human aesthetic, naturalistic, material, informational, recreational, health, emotional, and even spiritual benefits derived from the inherent human need to affiliate with nature (e.g., Kellert 2005; Kellert et al. 2008). This matrix of mutually beneficial people-nature interactions could fulfill what twentieth century microbiologist and philosopher Rene Dubos called ‘woeing of the earth’ suggesting “a relationship between humankind and nature ...of respect and love rather than domination. The outcome of this woening can be rich, satisfying, and lastingly successful if both partners are modified by their association so as to become better adapted to each other” (Dubos 1980, p. 68).

Biophilic design aims to create landscapes that enhance human physical and mental health and productivity by fostering beneficial connections between people and nature in places of cultural and ecological significance (Kellert et al. 2008). From a design perspective, six approaches to biophilic design have been identified, including: (1) environmental features (e.g., psychologically significant flora, fauna, and geology), (2) natural shapes and forms (e.g., simulation of natural features and organic forms, plant and animal motifs), (3) natural patterns and processes (e.g., sensory variability, growth and change, similar forms at different scales), (4) light and space (e.g., natural light, spatial variability, transitional inside-outside spaces), (5) place-based relationships (e.g., cultural connection to place, use of local and indigenous materials, sense or spirit of place), and (6) evolved human relationships to nature (e.g., prospect and refuge, order and complexity, innovation and security) (Kellert 2008). Much biophilic design has been focused on the built environment rather than taking a

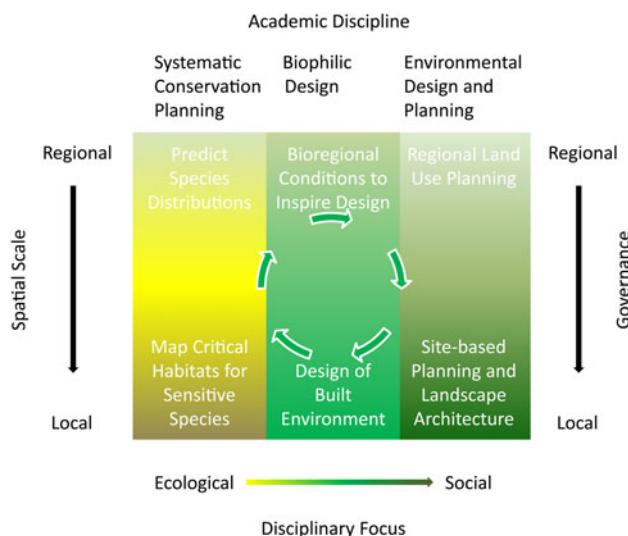


Fig. 1 Integrating biodiversity conservation and human health across multiple scales. Predicting species distributions for those organisms most sensitive to land use change happens at the regional scale first in the *upper left*. Design of the human living environment happens at the regional scale first in the *upper right* with traditional regional land planning (e.g., transportation and energy infrastructure). Regional climatic and soils conditions constrain design of the built environment in the center. Biophilic design is located in the center because it intentionally integrates ecological and social concerns to produce sustainable built environments

broader landscape view. We suggest that biophilic design can serve as a necessary link and integrator between existing approaches to plan for biodiversity conservation (Fig. 1).

CONCLUSION

Numerous global challenges to sustainability present an opportunity to integrate new perspectives. A way to envision our proposal is that species most sensitive to habitat conversion are the logical organisms from which to derive boundaries for the future use of space (i.e., Trombulak et al. 2010). If we choose to provide the infrastructure for sensitive species first (conservation biology supplies the information on habitat conservation priority and management), the ideal infrastructure for long-term sustainability can follow in the “negative space”. In fact, new research is doing just that: using species distribution models to identify suitable areas for biofuels production (Evans et al. 2010). We recognize that habitat conservation for a particular species is a sometimes elusive goal, because while a biophysical arena may be preserved for future evolution, individual species may wink out as climate and other atmospheric changes accumulate (Anderson and Ferree 2010).

We also recognize the perception that elevating the protection of habitat for sensitive species over immediate

humanitarian concerns presents a social justice issue (e.g., Adams et al. 2004). Biophilic design addresses this issue because it suggests that preserving habitat will actually enhance human well-being (i.e., psychological, physical, environmental). By focusing on the habitat needs of the most sensitive species, human settlements could impose spatial limits on themselves, protect species distributions, and—we hypothesize—reap enhanced social and ecological benefits.

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Robert F. Baldwin (✉)

Address: Department of Forestry and Natural Resources, Clemson University, 261 Lehotsky Hall, Clemson, SC 29634-0317, USA.
e-mail: baldwi6@clemson.edu

Robert B. Powell

Address: Department of Parks, Recreation and Tourism Management, Clemson University, 263 Lehotsky Hall, Clemson, SC 29634-0735, USA.

Address: Department of Forestry and Natural Resources, Clemson University, 263 Lehotsky Hall, Clemson, SC 29634-0735, USA.
e-mail: rbp@clemson.edu

Stephen R. Kellert

Address: School of Forestry and Environmental Studies, Yale University, 195 Prospect Street, New Haven, CT 06511, USA.

Address: Bio-Logical Capital, 1555 Blake Street, Denver CO80202, USA.
e-mail: stephen.kellert@yale.edu